

May 7th 2008, A. Pany, J. Böhm

## **Twin antenna simulations with PPP KF**

### *Specifications:*

|           |                                                                                     |
|-----------|-------------------------------------------------------------------------------------|
| schedule: | random schedule                                                                     |
| software: | PPP KF                                                                              |
| zwd:      | Vienna turbulence                                                                   |
| clk:      | random walk + integrated random walk, ASD: 1e-14 @ 50 min                           |
| wn:       | 4/sqrt(2) ps per station                                                            |
| zwd:      | random walk, 0.7 ps <sup>2</sup> /s                                                 |
| grd:      | random walk, 0.5 ps <sup>2</sup> /s                                                 |
| SH:       | SH11, random walk, 0.01 ps <sup>2</sup> /s                                          |
| clk:      | deterministic rate + random walk offset, var. rate for offset: 1 ps <sup>2</sup> /s |

elevation dependent downweighting as proposed by J. Gipson:

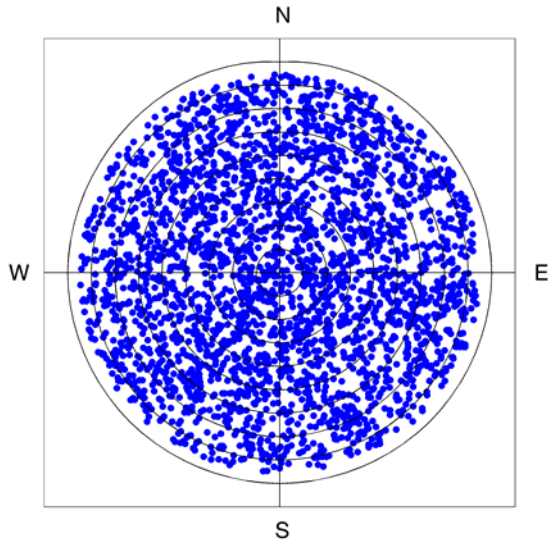
$$\text{sig}^2 = \text{obs\_sig}^2 + (10\text{ps}/\sin(\text{el}))^2$$

Simulations for a single station were carried out to show, how much improvement can be expected when using twin antennae and to investigate whether it is better to have two observations at exactly the same time for the estimation of clock and zenith wet delay or at different times, when using twin antennae.

Three scenarios were simulated:

- S1) Two co-located antennae observe every 30 s at the same time.
- S2) Two co-located antennae observe every 30 s where the observations are shifted by 15s.  
(This scenario is equal to one antenna observing every 15 s.)
- S3) One antenna observes every 30 s.

For each of the two antennae, one fictitious schedule was generated. The schedule was generated purely randomly, i.e. no real sources were used. The cutoff elevation angle was chosen to be 5°. Sky coverage over 24 hours for one of the two antennae is shown in Figure 1.



**Figure 1:** Sky coverage of one antenna over 24 hours.

Since the observations of the antennae will be correlated spatially and temporally, the schedules were merged before simulating the turbulent equivalent zenith wet delay time series. The simulated equivalent zenith wet delay time series was then splitted again to obtain one time series for each antenna. Turbulent equivalent zenith wet delays were generated with the Cn and H values of stations NY, TA and WS, but for all three stations the same schedule was used. For each station, time series were simulated for 250 days.

Assuming that both antennae use the same station clock, only one clock time series per day was generated with an ASD of  $1e-14$  @ 50 min.

For each of the antennae, a sequence of white noise was generated ( $4/\sqrt{2}$  ps).

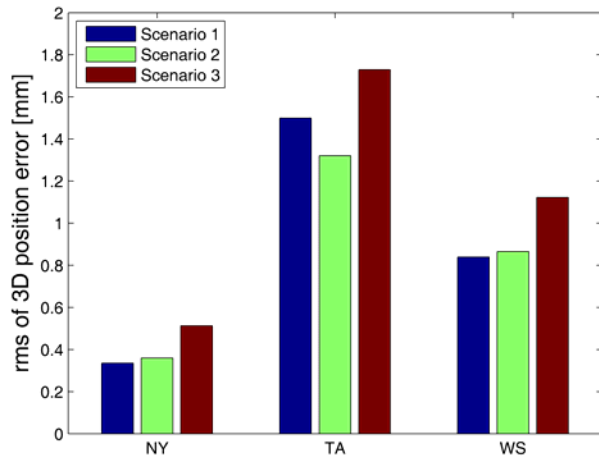
For all three scenarios, only one clock and one troposphere were estimated. Scenario 3 was processed with the PPP KF as usual. Scenario 2 is the same as if one antenna would observe every 15 s. Thus, the schedules of the two antennae were merged and processed as if one antenna had observed every 15 s. For Scenario 1, two cumulative delay time series were set up:

$$\begin{aligned} delay_1 &= zwd_1 \cdot mfw(el_1) + clk + wn_1 \\ delay_2 &= zwd_2 \cdot mfw(el_2) + clk + wn_2 \end{aligned}$$

No differencing was performed. For each time epoch, two observations were used to estimate one troposphere and one clock.

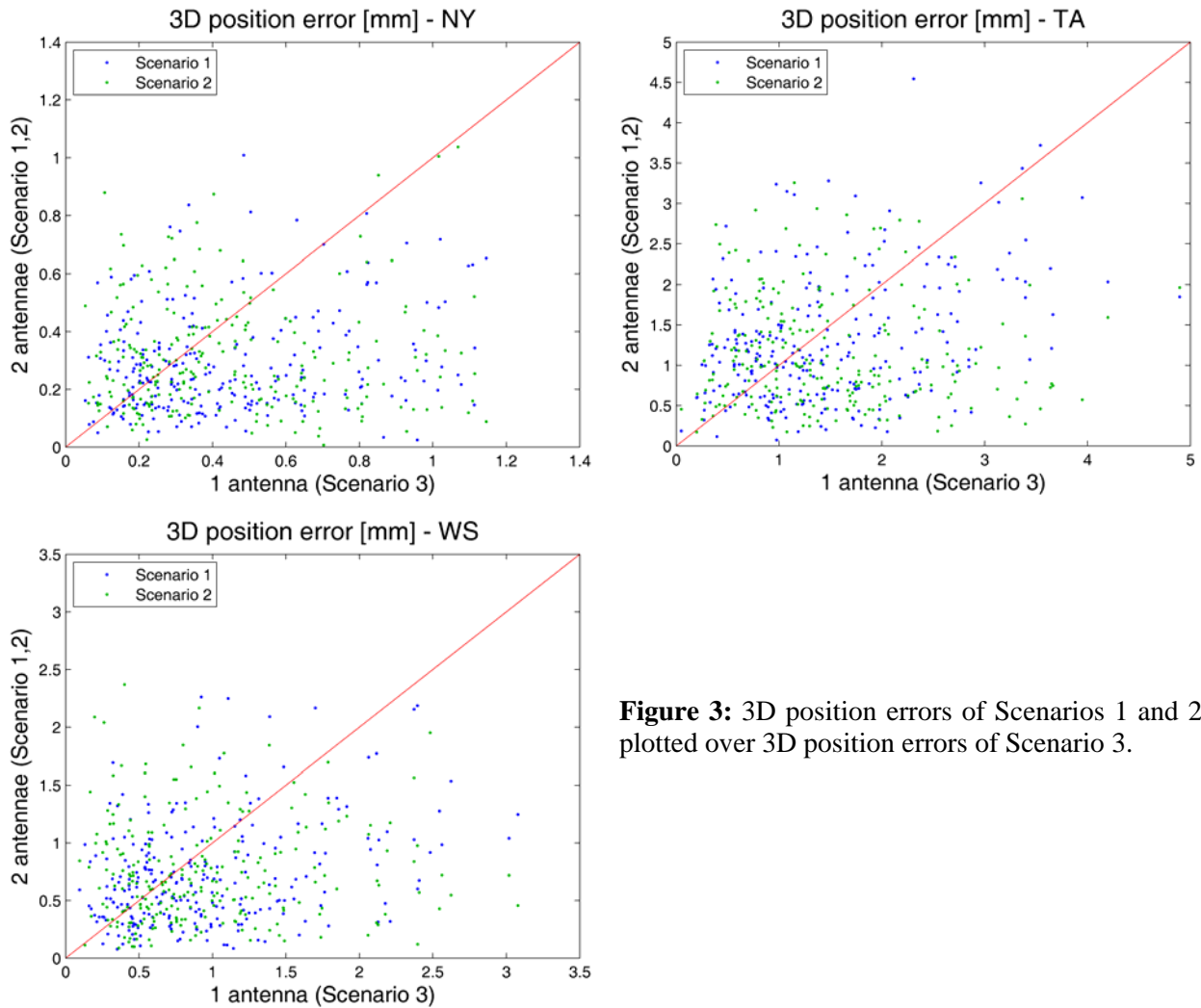
The analysis was performed with the standard solution (i.e. gradients, no elevation dependent weighting). The random schedules differ slightly from the VLBI2010 schedules we are normally working with, e.g., the random schedules have more high and less low elevations, sky coverage is not optimized, and since no real sources are used, sky coverage over 24 hours is pretty uniform.

Figure 2 shows bar plots of rms of 3D position error for the three scenarios. For all three stations and both solutions, the scenarios involving two antennae yield smaller rms values than the single antenna scenario. For NY and WS, Scenario 1 yields best results - the differences to results of Scenario 2 are not significant, though. For TA, Scenario 2 yields better results than Scenario 1.

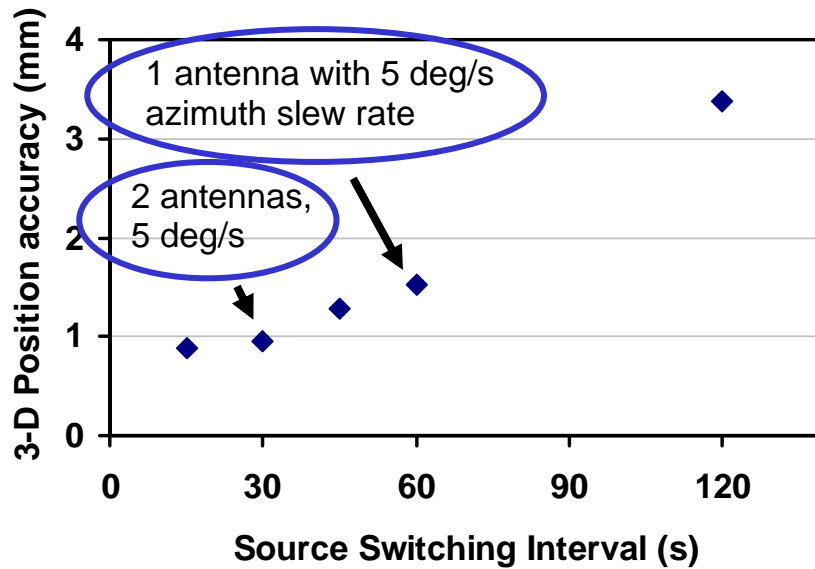


**Figure 2:** rms of 3D position errors. Scenario 1 (blue): 2 antennae observing every 30 s at the same time, Scenario 2 (green): 2 antennae observing every 30 s but in turn (shifted by 15 s), Scenario 3 (red): 1 antenna observing every 30 s.

In Figure 3, 3D position errors for the 2 antennae scenarios (Scenario 1 and 2) are plotted over the 3D position errors of the single antenna scenario (Scenario 3) for all 250 days.



**Figure 3:** 3D position errors of Scenarios 1 and 2 plotted over 3D position errors of Scenario 3.



**Figure 4:** 3D position accuracy vs. source switching interval (from Bill’s EGU08 presentation)

It can also be seen in Figures 2 and 3, that the improvement with twin antennae is not very large. Figure 4 is from Bill’s presentation “VLBI2010: A new VLBI System for Geodesy and Astrometry (In Search of the Millimeter)” at EGU 2008 in Vienna and shows 3D position accuracy versus source switching interval. As can be seen from Figure 4, the improvement from 30 s to 15 s switching interval is not very large, which is in good agreement with the PPP results presented here. When repeating the twin antenna simulations with observations every 60 s (shifted by 30 s for Scenario 2), a larger improvement might be observed.